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AFSA

AN ANALYTICAL METHODOLOGY FOR DETERMINING CRUISE-MISSILE DORMANT RELIABILITY (U)

JUNE 82

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, D.C.

REPLY TO ATTN OF: SAT

SUBJECT: An Analytical Methodology for Determining Cruise Missile Dormant Reliability

TO:

1. The attached scripted briefing was presented at the AFSC hosted Dormant Reliability Workshop at Andrews AFB, MD on 31 Mar 82. The objective of this briefing is to present a strawman analytical methodology for determining cruise missile dormant reliability. This analytical approach is offered as a short-term complement to the testing program. Even the accelerated testing program does not offer a short-term answer to the critical questions about the dormant reliability of cruise missiles.

2. This briefing was initially prepared as a monograph intended as a thought piece. However, the workshop offered an opportunity for instant feedback, so the format was changed.

3. At the workshop, two primary weaknesses of the methodology were presented. The first weakness was that there is a lack of data of sufficient detail to perform the analysis on known systems. While the overall reliability of these systems is known, the detailed piece-part level information is not maintained. The second weakness is that this method will actually take too long to be of much marginal value as a complement to the testing program.

4. I do not believe that either of these weaknesses poses a significant obstacle to use of this analytical method. At the same dormant reliability workshop, Mr. M. Q. Bahan of the US Army Missile Command (DRASMI-QSC), presented a briefing on an extensive data collection and analysis system. This data and system are maintained at the piece-part level. Thus, at least one data source on known missiles is available. The time to actually perform the data gathering and analysis is a function of many variables. These variables include availability of data and number of analysts and engineers assigned to the project. As noted above, the data are available. Since the method is a combination of classical reliability analysis techniques and relatively simple statistical correlation algorithms, the time needed to complete this analysis should be fairly short if enough people are assigned.

5. In summary, the current testing program, which will yield sufficient empirical data for determining the actual dormant reliability of cruise missiles, is in progress and will be for years. In the interim, I am proposing an analytical methodology, using classical engineering and statistical techniques, for estimating dormant cruise missile reliability.

Air Force

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Studies & Analyses

AN ANALYTICAL METHODOLOGY FOR DETERMINING CRUISE MISSILE DORMANT RELIABILITY

Jun 82

Slide 1

The purpose of this briefing is to present an analytical methodology for determining cruise missile dormant reliability (CMDR). The reason for suggesting such a methodology is that there is currently no other means of arriving at a confident estimate of CMDR without resorting to large scale, long-term testing. Such testing is planned and is being implemented for the Air Launched Cruise Missile (ALCM). But the answer to the question, What is the dormant failure rate of the ALCM fleet: Will not be available for over 2 years.

PURPOSE

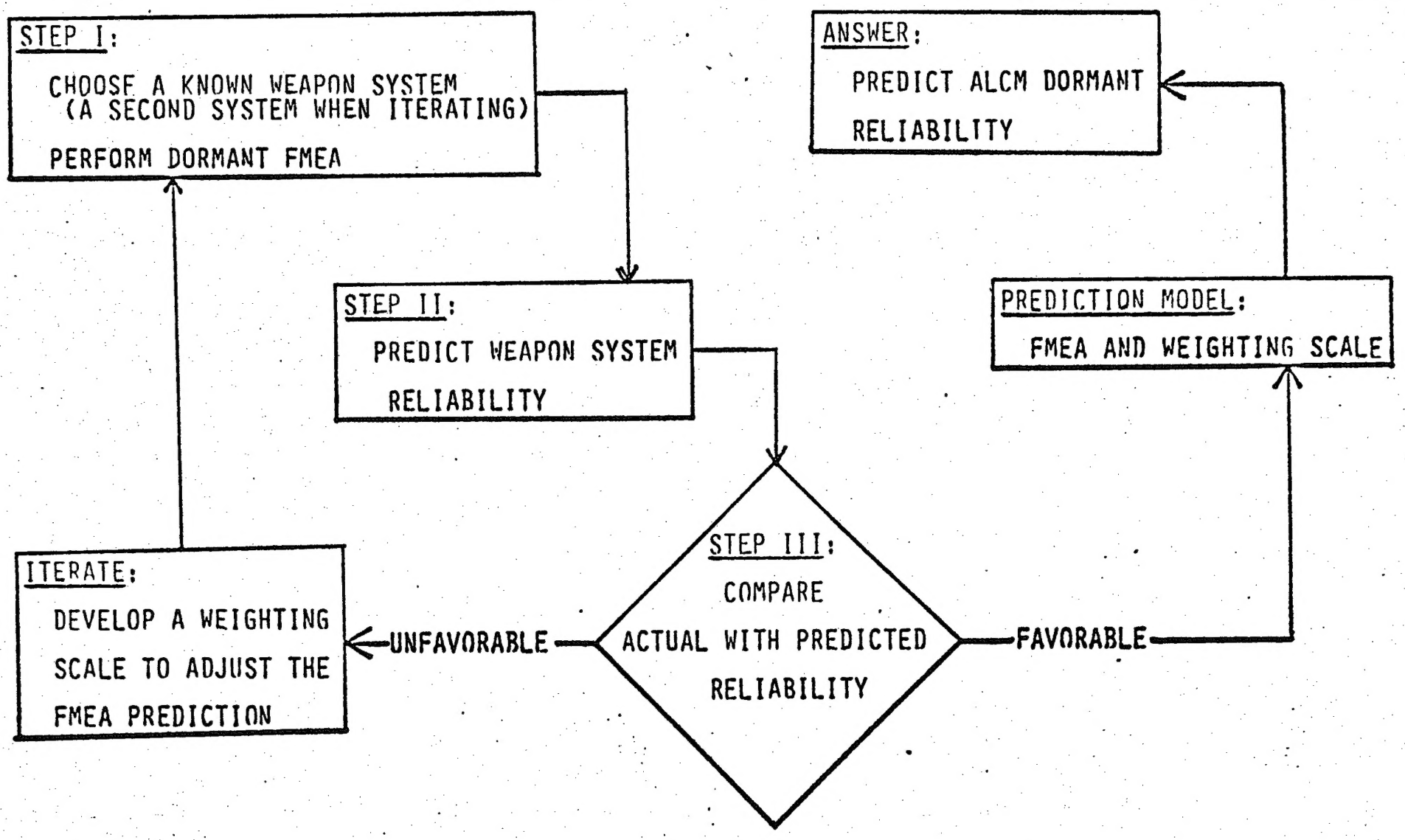
OPERATORS - NEED DATA FOR EFFECTIVE FORCE PLANNING

LOGISTICIANS - NEED DATA FOR EFFICIENT SUPPORT PLANNING

Slide 2

There are two primary reasons this question needs to be answered now. First, operations staffs require systems reliability data for effective force planning. Second, logistics staffs need reliability data for efficient support planning.

METHODOLOGY LOGIC



Slide 3

This slide shows the logic of a three-step, iterative methodology for determing an answer to the question.

STEP I

- CHOOSE A WEAPON SYSTEM
  - COMPARABLE COMPLEXITY
  - AVAILABLE RELIABILITY DATA BASE

- PERFORM FAILURE MODES AND EFFECTS ANALYSIS (FMEA)
  - PERFORMED BY ENGINEERS
  - FAILURES CAUSED BY AGING AND HANDLING

STEP I

The first step is to choose a weapon system similar to the ALCM in complexity on which we already have sufficient reliability data. For example, one candidate is the HARPOON missile. A team of engineers performs a Failure Modes and Effects Analysis (FMEA) on the chosen weapon. The engineers should be instructed to search for failure modes which result from aging and normal handling. The environment in which the weapon ages and the normal handling expected during dormancy should be described. For example, if the weapon is stored in a desiccated cannister, moisture is not normally a problem during aging. Similarly, a weapon which is stored in a bunker and not disturbed until the end of its shelf life does not require much analysis to determine handling induced failures. Conversely, a system like ALCM which is not protected from the environment when on alert, will have many environmental factors, such as weather, which need to be considered when analyzing aging failure modes. Similarly, the alert/igloo storage/maintenance test cycle of ALCM requires careful consideration of handling induced failures. Using the results of the FMEA, the next step is to predict the reliability of the chosen weapon.

STEP II

PREDICT SYSTEM RELIABILITY

- USE FMEA TO IDENTIFY FAILURE MODES
- DETERMINE THE PIECE PART FAILURE RATES
- DEVELOP SYSTEM LEVEL FAILURE PROBABILITY RATE AS A FUNCTION OF TIME

STEP II

To predict the system reliability from the FMEA requires the engineers to determine which parts of the system fail and at what time this failure occurs. Failure of a critical part may be the cause of overall system failure; or, failure of a number of minor components may result in system failure. Whatever the failure mechanisms identified, the individual failure rates for the parts should be combined, using standard statistical techniques, into a probability density function which describes the overall system failure rate over time. This probability density function <u>is</u> the reliability estimate.

STEP III

- COMPARE ACTUAL TO PREDICTED RELIABILITY

  IF FAVORABLE - USE THE METHOD TO PREDICT ALCM RELIABILITY

  IF UNFAVORABLE - ITERATE

STEP III

The last step in the process is to compare the actual reliability of the system with the predicted reliability. If they compare favorably use the same FMEA techniques and statistical development to predict ALCM reliability. If they do not compare favorably, conduct further analysis of the components making up the actual and estimated figures. This process entails correlating the failure modes determined using the FMEA with the actual failure modes of the system. The high correlation modes are then used to develop a weighting scale. The weighting scale is adjusted so the predicted reliability and the actual reliability compare favorably. Now the analyst must iterate through the three steps again.

ITERATE

DEVELOP A WEIGHTING SCALE

- MAKE FMEA BASED PREDICTION COINCIDE WITH ACTUAL DATA
- CORRELATE BY FAILURE MODE/EFFECT

GO TO STEP I AND CHOOSE ANOTHER APPROPRIATE SYSTEM

ITERATE

The next iteration requires choosing a second weapon which is also similar to the ALCM in complexity, again on which we have sufficient reliability data. Proceed through the three steps, as described with one modification to the second step. In combining the individual failure rates to develop the probability density function, an adjustment is made using the weighting scale developed on the previous interation. In the third step the comparison of actual and predicted reliability is again made. As before, if the comparison is unfavorable, the weighting scale is modified. Then proceed with another iteration. Continue to iterate until a favorable comparison is achieved.

PREDICTION MODEL

PREDICT ALCM DORMANT RELIABILITY

- USE FMEA RESULTS ON DESIRED WEAPON SYSTEM (IE ALCM) AS IN STEP II
- ADJUST RELIABILITY USING THE FAILURE WEIGHTING SCALE, IF NECESSARY

PREDICTION MODEL

When a favorable comparison is achieved, apply the weighted scoring system to the ALCM dormant FMEA. The result is the desired ALCM dormant reliability probability density function, hence the dormant failure rate.

SUMMARY

The process just described is an analytical methodology for deriving a CMDR rate. This rate can now be used by operations and logistics planners to complete their functions. The testing program will eventually yield a reliability rate for the fielded system, but this methodology offers a logical approach to determining that rate until test data are available.